Risk Report

FEMA Risk MAP Study for Pacific County, Including the Cities of Ilwaco, Long Beach, Raymond, and South Bend, and the Shoalwater Bay Tribe

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FEMA

DEPARTMENT OF ECOLOGY State of Washington

WASHINGTON STATE DEPARTMENT OF Natural Resources

Sea Grant Washington

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1. Introduction

This report outlines the risk assessment results and findings for the Federal Emergency Management Agency's (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) Study. All results, databases, and maps used to generate this report are provided in the Risk Assessment Database included with this report. The Risk Report has two goals: inform communities of their risks related to certain natural hazards, and enable communities to act to reduce their risk. State and local officials can use the summary information provided in this report, in conjunction with the data in the risk database, to:

- **Update local hazard mitigation plans, shoreline master programs, and community comprehensive plans** – Planners can use risk information in the development and/or update of hazard mitigation plans, comprehensive plans, future land use maps, and zoning regulations. For example, zoning codes can be changed to provide for more appropriate land uses in high hazard areas.
- **Update emergency operations and response plans** – Emergency managers can identify low-risk areas for potential evacuation and sheltering. Risk assessment information may show vulnerable areas, facilities, and infrastructure for which planning for continuity of operations plans (COOPs), continuity of government (COG) plans, and emergency operations plans (EOPs) would be essential.
- **Communicate risk** – Local officials can use the information in this report to communicate with property owners, business owners, and other citizens about risks and areas of mitigation interest (AOMIs).
- **Inform the modification of development standards** – Planners and public works officials can use information in this report to support the adjustment of development standards for certain locations.
- **Identify mitigation projects** – Planners and emergency managers can use this risk assessment to determine specific mitigation projects. For example, a floodplain manager may identify critical facilities that need to be elevated or removed from the floodplain.

The intended audience for this report includes, but is not limited to:

- Local Elected Officials
- Community Planners
- Emergency Managers
- Public Works Officials

2. Risk Assessment

A risk assessment analyzes how a hazard impacts the built environment, population, and local economy. In hazard mitigation planning, risk assessments are the basis for mitigation strategies and actions. A risk assessment defines the hazard and enhances the decision-making process. The risk assessments in this report were completed using a free FEMA risk assessment tool, Hazus, which estimates flood and earthquake losses for specific buildings. A complete list of every building in Pacific County was incorporated into the Hazus model. Other hazards were assessed through a vulnerability assessment. To assess potential community losses, the following information was collected:

- Local assets or resources at risk to the hazard
- Physical features and human activities that contribute to that risk
- Location and severity of the hazard

This report contains the following types of risk analysis to help individuals describe and visualize the risk for a variety of hazards at the jurisdictional levels:

1. Coastal Flood Risk Assessment: Hazus Estimated Loss Information
2. Earthquake Risk Assessment: Hazus Estimated Loss Information
3. Landslide Risk Assessment: Vulnerability Assessment
4. Tsunami Risk Assessment: Vulnerability Assessment

A detailed methodology of the risk assessment is listed in the appendix.

3. Pacific County Coastal Risk MAP Overview

The Pacific County Coastal Risk MAP project began in 2010 and is expected to continue through 2015. FEMA's Service Provider, the Strategic Alliance for Risk Reduction (STARR), and the Washington Department of Natural Resources (WADNR) are contributing to this project.

Project Milestones

Project milestones are the estimated completion timeframes for key tasks or events that must be accomplished to complete a Risk MAP Project phase. They serve as progress indicators and are the basis for planning future Risk MAP meetings. However, all project milestones are subject to change due to changes in scope, delays in data acquisition, and other unforeseen complexities within a study. The project timeline is shown in Table 1.

Table 1: Project Timeline

Task Name	Time of Completion
Engineering Analysis	December 2012
Flood Risk Review Meeting	January 29, 2013
Preliminary Map Production	August 2013
Final CCO & Public Meeting	November-December 2013
Letter of Final Determination	November 18, 2014
Resilience Meeting	January 8, 2015
Effective Map Production	May 18, 2015*

*Dates are shown as projected

At least three meetings between FEMA, the State, and the communities affected by this study will occur: the Flood Risk Review (FRR), Final Community Coordination Officer (CCO), and Resiliency meetings. The input data, methodology, and draft results were presented at the FRR meeting, which was held on January 29, 2013, following the completion of the Coastal Analysis task. The Final CCO meeting, where the preliminary results of the Flood Insurance Study were reviewed and discussed with community officials, was held on November 14, 2013. A public meeting was held in December 2013. The Resilience meeting was held on January 8, 2014. A Resilience meeting continues the goal of building local capacity for implementing priority mitigation activities within the watershed.

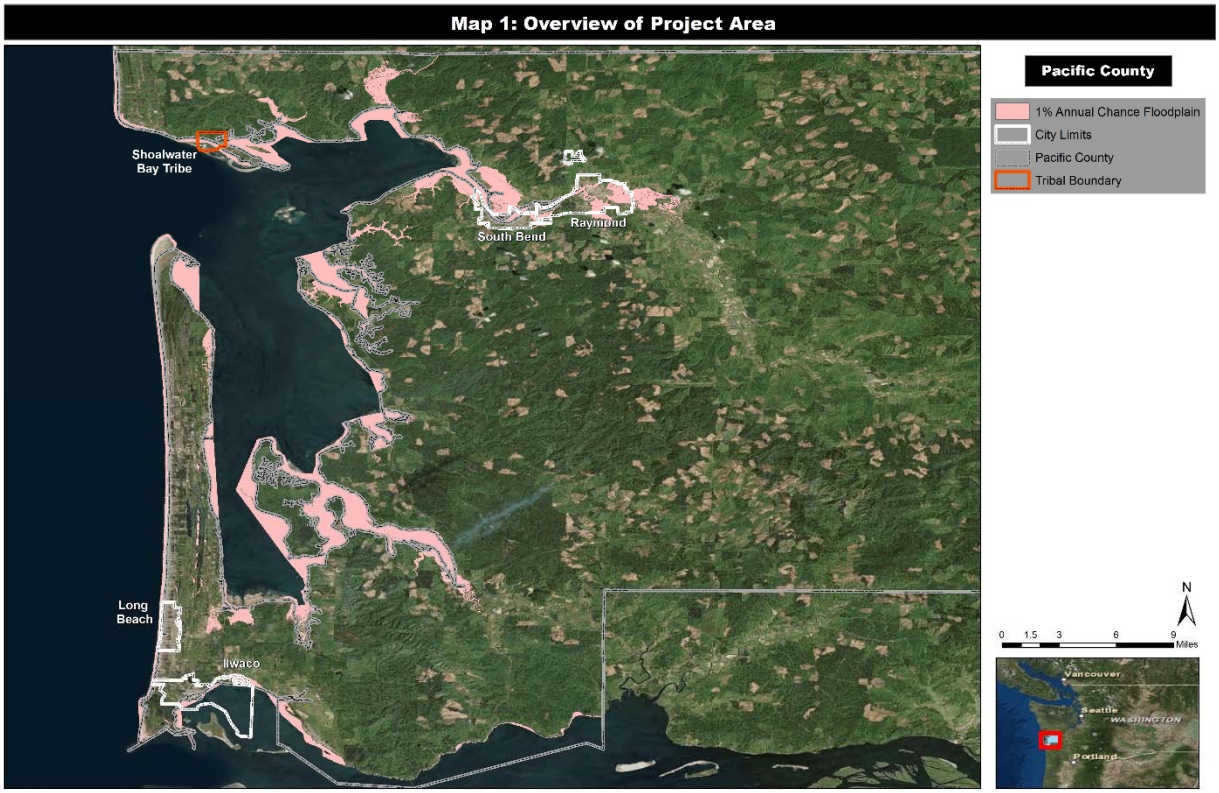
Project Scope

The scope of this project includes the entire Pacific County coastline, as well as some riverine work for the South Fork Naselle River, the Naselle River, Salmon Creek, and the Willapa River, as shown in Map 1.

Additional Project Deliverables

This project also includes standard Risk Products (Risk Report/Map/Database), as well as Flood Risk Datasets (Changes since Last FIRM, Flood Depth and Analyses Grids, and Flood Risk Assessment). The Risk MAP datasets were completed in winter 2014.

Map 1: Overview of Project Area

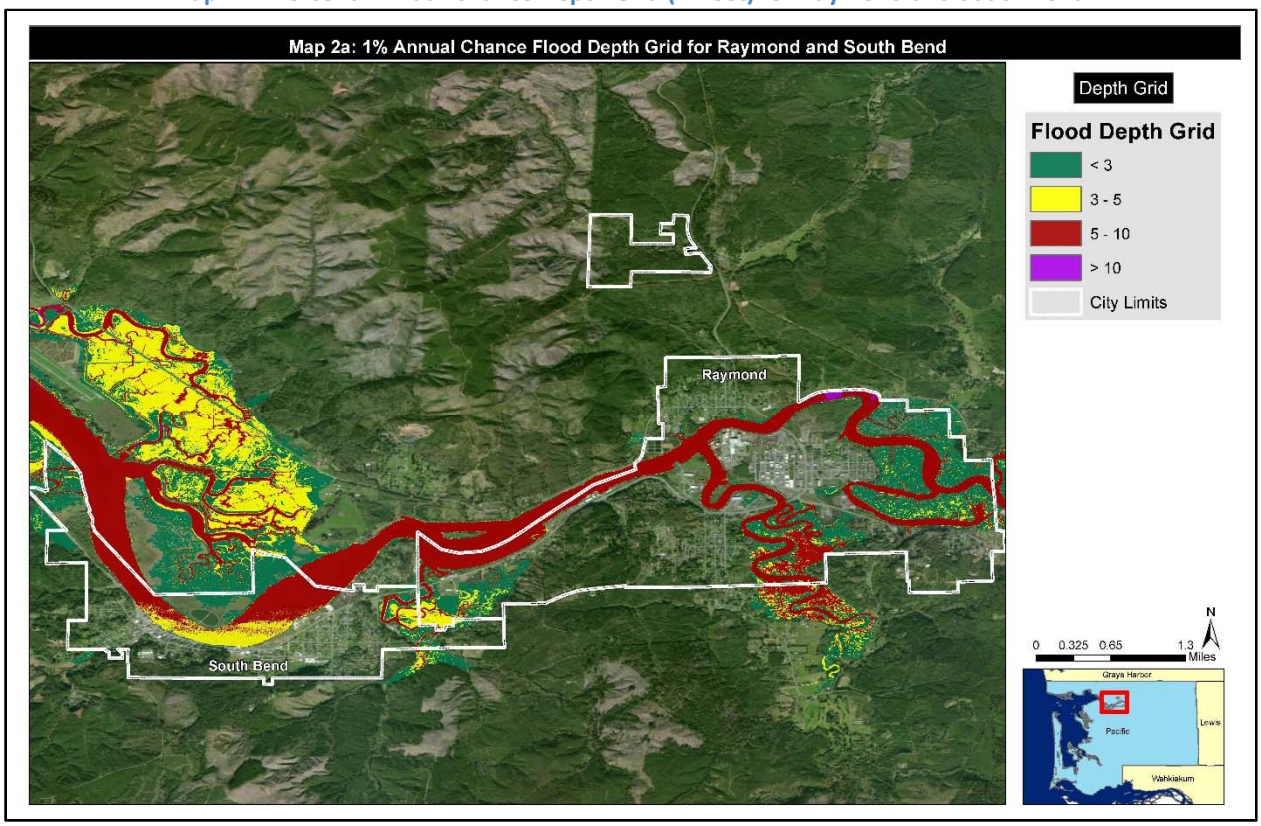


4. Coastal Flood Risk Assessment

Coastal Flood Hazard Overview

FEMA created new Flood Insurance Rate Maps (FIRMs) for Pacific County, which included updated flood modeling for the coastline for Ilwaco, Long Beach, Raymond, South Bend, the unincorporated areas of the County, and the Shoalwater Bay Tribe. In addition to new FIRMs, FEMA developed flood risk assessment products that were used in this report. Depth grids for the base (1-percent-annual-chance) flood were created for the coastal areas. The depth grids, generated from the coastal flood model, show the level of flooding (in feet) for each pixel and each flood frequency. Depth grids were used in this risk assessment to determine properties impacted by flooding. Map 2 shows the 1-percent-annual-chance depth grid for the areas of Raymond and South Bend.

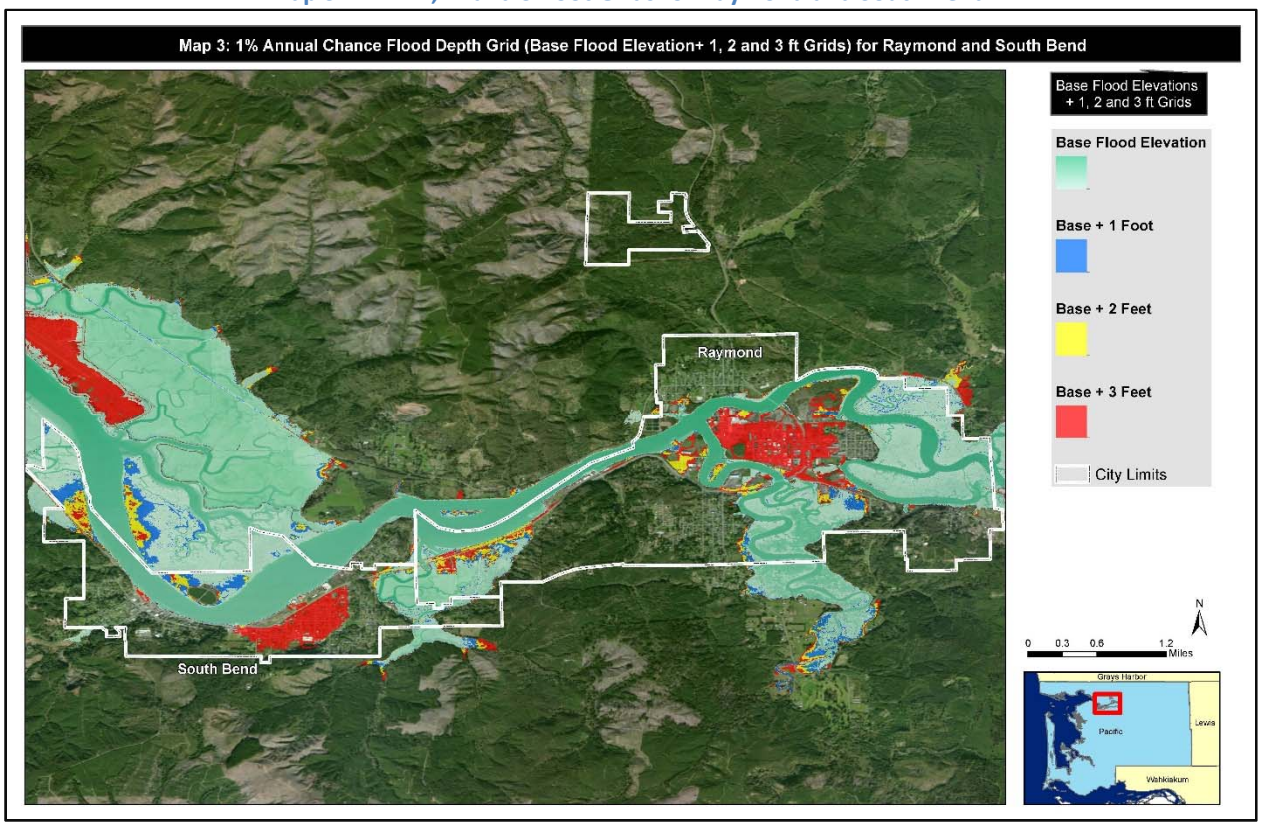
Map 2: 1-Percent-Annual-Chance Depth Grid (in feet) for Raymond and South Bend



The 1-percent-annual-chance depth grid shown above can also be used as an outreach tool to illustrate flood hazards. Properties in these areas would be excellent choices for mitigation projects. Some of these potential mitigation projects are highlighted in the individual community sections of this report (see Section 7). For non-coastal areas, a vulnerability assessment was completed.

In addition to the depth grid, a BFE+ grid was created to show increases of 1, 2, and 3 feet above the Base Flood Elevation (BFE). This elevation grid presents the extent of events higher than the base flood, including potential sea level rise. This product is meant to inform local communities about possible future risk, but is not a substitute for detailed sea-level-rise modeling. The BFE+ grid for the Raymond and South Bend area is shown on Map 3.

Map 3: BFE+ 1-, 2- and 3-Foot Grids for Raymond and South Bend



The BFE+ grid can be used to identify areas affected by increased storm surge, storms greater than the 1-percent-annual-chance event, and areas potentially affected by sea level rise. This dataset can be used for future land-use and comprehensive planning.

Flood Risk Assessment Overview

This risk assessment includes the communities shown in Table 2:

Table 2: Community Characteristics

Community Name	Total Population	CRS Community	Flood Claims	Repetitive Loss Properties	Total Policies	Total Insurance Coverage
Unincorporated County	20,984	No	96	3	1,050	$247,401,200
Ilwaco	1,304	No	2	0	30	$6,654,900
Long Beach	1,400	No	1	0	135	$32,582,700
Raymond	3,009	No	35	3	51	$10,032,100
South Bend	1,770	No	11	1	100	$12,461,100
Shoalwater Bay Tribe	891	No	0	0	0	$0

The community overview summarizes community characteristics at the community level. Data were obtained from FEMA, U.S. Census Bureau, and the communities.

The information in Table 2 highlights communities that are already affected by flooding, including repetitive loss properties and the number of flood claims. In addition, the amount of insurance coverage can be compared to the dollar losses shown in Table 3 to determine if enough coverage exists for a specific event.

The flood risk assessment was completed using local parcel/assessors data from Pacific County, as well as the coastal depth grids derived from this Risk MAP project. For this assessment, a coastal flood depth grid was used for the coastal area shown in Map 2. For the riverine areas, a vulnerability assessment was completed for buildings in the Special Flood Hazard Area (SFHA). Individual building data were incorporated into Hazus, which allows losses to be reported at the building level. The essential facilities were also updated in Hazus. Please refer to the appendix for detailed methodology on incorporating local data into Hazus. Table 3 highlights building values and the percentage of buildings located within the floodplain, by community. In addition, losses are highlighted by community for the mapped coastal floodplains, and a count of buildings in SFHAs by community is included.

Table 3: Coastal Special Flood Hazard Area Assessments

Community	Total Estimated Building Value	Total Number of Buildings	Number of Buildings in the Coastal SFHA	Percent of Buildings in the Coastal SFHA	Building Dollar Loss for a 1% Annual Chance Flood Event	Loss Ratio (Dollar Losses/ Total Building Value)	Number of Buildings in Zone VE	Number of Buildings in Zones AE, A, AO, AH
Unincorporated County	$917,115,720	12,654	96	0.8%	$647,288	0.1%	2	193
Long Beach	$154,513,884	1,406	0	0.0%	N/A	N/A	N/A	N/A
Ilwaco	$87,997,658	669	87	13.0%	$335,751	0.4%	N/A	94
Raymond	$117,357,628	1,235	5	0.4%	$0	0.0%	N/A	5
South Bend	$82,052,427	790	6	0.8%	$15,794	0.02%	N/A	7
Shoalwater Bay Tribe	$5,388,653	41	0	0.0%	N/A	N/A	N/A	N/A
Total	**$1,364,425,970**	**16,795**	**194**	**1.2%**	**$998,833**	**0.1%**	**2**	**299**

Note: Loss information is included for communities in the coastal floodplain. Dollar losses are reported as well as a loss ratio, which is calculated by the total losses/total building value. Also included is a count of buildings in Zone VE, which is the 1-percent-annual-chance coastal high hazard flood zone, as well as the buildings in Zones A, AE, AO, and AH, which are riverine and/or coastal 1-percent-annual-chance floodplains.

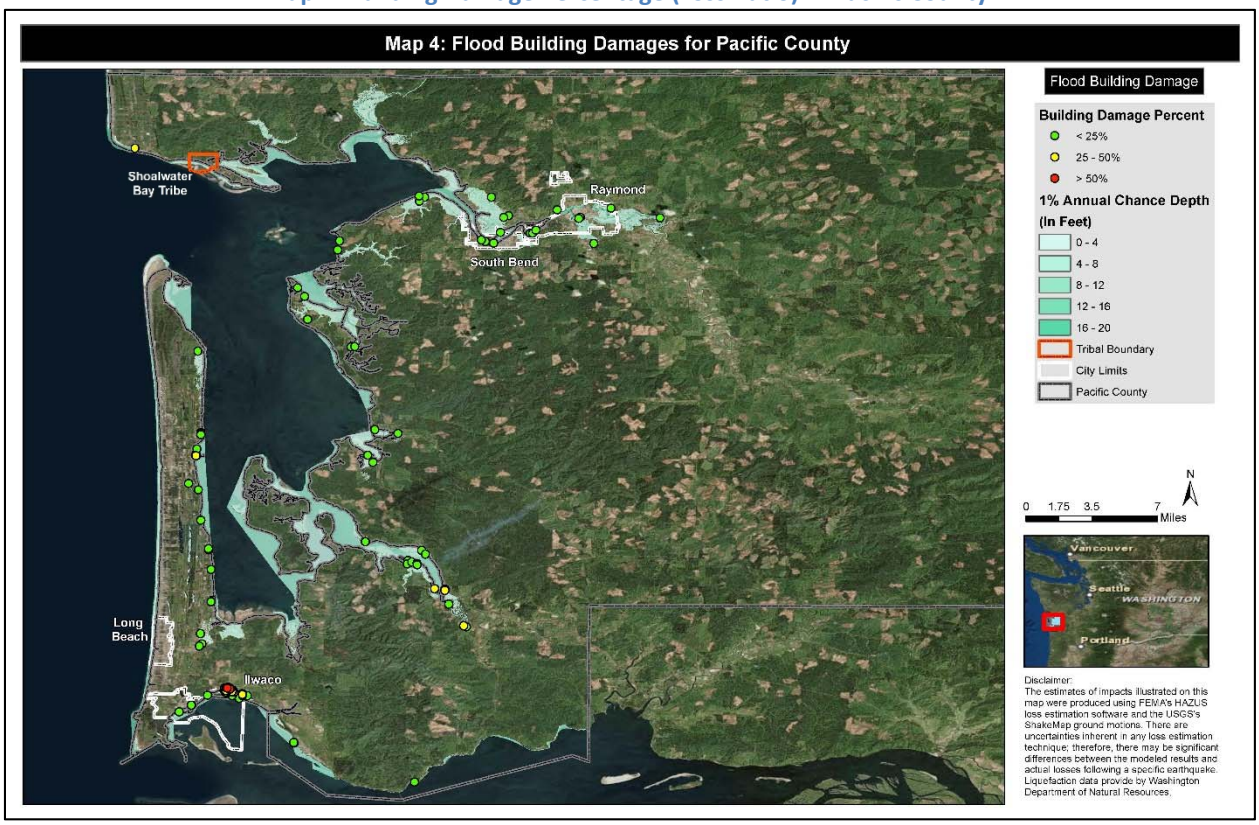
The City of Ilwaco has the largest percentage of buildings in the SFHA (1-percent-annual-chance flood zone). In addition, Ilwaco has the highest loss ratio, which compares the losses due to flood to the overall building value within the community. Not all buildings within the floodplain experience damage, due to the level of flooding as well as current floodplain regulations. In addition, the number of buildings in the SFHA is highlighted. As shown in Tables 2 and 3, a total of 1,366 National Flood Insurance Program (NFIP) policies are in effect across all the communities, although a total of 194 buildings are in the SFHA. The size of the mapped floodplains was reduced in many areas of the county on the new updated maps. These revisions were due to the use of more detailed data, such as topography, and new and improved flood modeling. Although structures may be removed from the floodplain, it is still beneficial for those

property owners to maintain their flood insurance, which is available at a reduced rate if their property is shown outside the SFHA. Flood insurance covers riverine and coastal flooding, but also tsunamis. As shown in Table 7, over 11,000 buildings are in the tsunami zone; with only 1,366 flood insurance policies in effect, many properties in the tsunami area are not covered.

The buildings in Zone VE are highlighted specifically because they are subject to 3 feet or more of wave inundation and are considered to be in a high hazard area due to the impacts of high-velocity waves. When calculating damages, the risk assessment only takes into account depth of water; therefore, the properties that are within Zone VE should use the loss information as a minimum level of risk.

The community results shown in Tables 2 and 3 give an idea of where the largest flooding risks are. This risk assessment includes information for every building in each community, so users can easily determine which buildings have the highest flood risk. Map 4 shows the building losses for a 1-percent-annual-chance event in Pacific County. Buildings shown in red and yellow have a potential to be damaged during a 1-percent-annual-chance flood event, based on the depth of flooding at their location and the height of the building.

Map 4: Building Damage Percentage (Loss Ratio) in Pacific County



Note: The damage percentage is calculated by the total building loss divided by the total building value. This percentage easily highlights the community's buildings that would have the most building damage.

The loss data from Hazus and the exposure analysis can highlight the areas affected by flooding and identify properties for mitigation projects, as well as additional outreach. The areas of greatest risk and those suited for potential mitigation actions will be shown in the community sections of this report (Section 7). All results, databases, and maps are provided in the Risk Assessment Database included with this report.

5. Earthquake Risk Assessment

Earthquake Hazard Overview

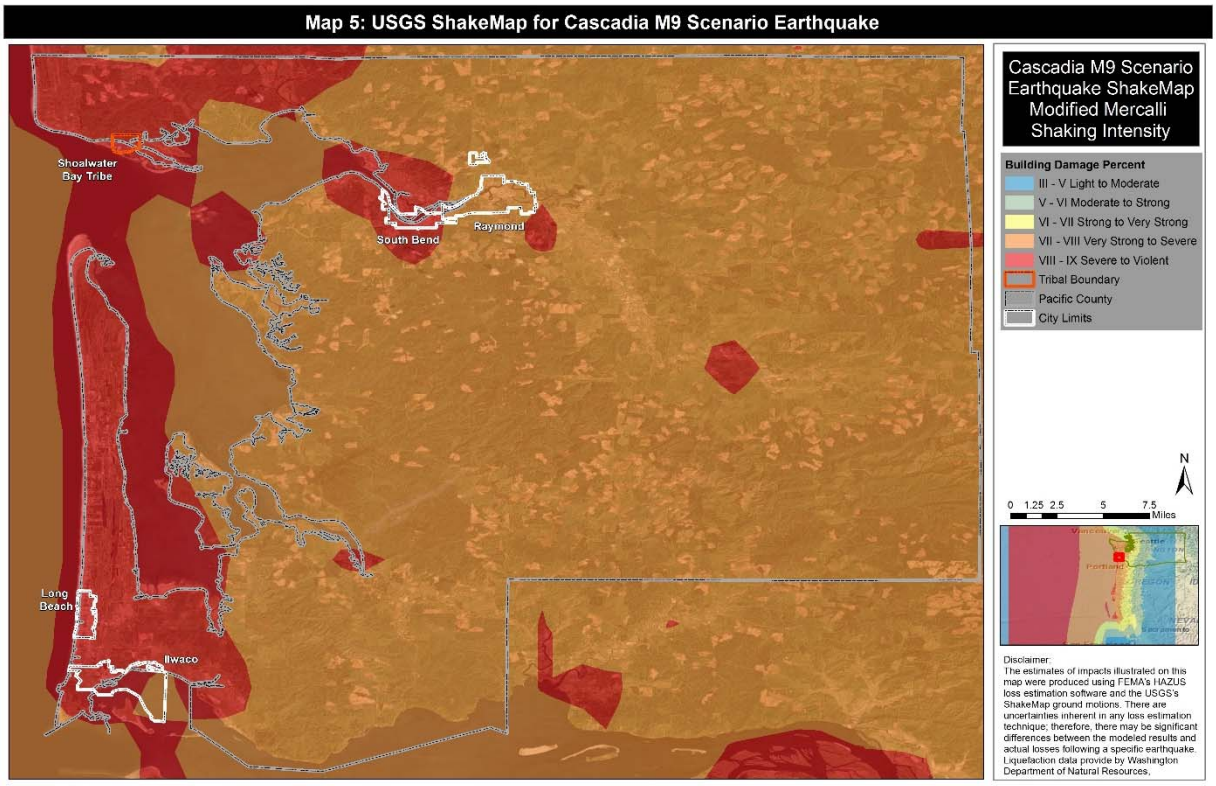
Although earthquakes have been reported in Pacific County from as early as the 1872 North Cascades event, no earthquake creating major damage has been definitively identified within the county prior to the advent of the Puget Sound Seismic Network (PNSN) in 1969. The largest earthquakes recorded in Pacific County by PNSN were a magnitude 3.3 (M3.3) event on September 6, 1981, midway between Raymond and Bruceport, and an M3.3 in the Willapa Hills in the northeast corner of Pacific County on March 18, 2012. These were located at depths of about 25 miles, which makes them Benioff zone events, a type of earthquake that takes place in the subducting crust. On the basis of seismic reflection profiling, McCrory (2003) infers an active fault, called the Willapa Bay fault zone, trending north-northwest in the bay and out to sea at the bay mouth. However, no contemporary shallow seismicity has been detected that can be associated with this fault, so the risk that it poses, if any, is unknown.

The largest earthquake threat to the county would likely be from a Cascadia subduction zone earthquake. Abundant physical evidence for an earthquake in AD 1700 includes evidence for abrupt tectonic subsidence along the Copalis River (cover photo) and the subsequent drowning of a spruce and cedar forest. This event, probably about M9, is the largest earthquake in Pacific County in the historic or paleoseismic record. The evidence for this earthquake is documented in Atwater and others (2005) and Goldfinger and others (2012). A repeat of this event dominates the hazard for the county in the National Seismic Hazard Map and will be the basis for this report's assessment of earthquake risk.

ShakeMaps

Maps depicting the shaking intensity and ground motion following an earthquake, called ShakeMaps, can be produced in near-real time for events or created for specific scenarios by regional seismic network operators in cooperation with the U.S. Geological Survey (USGS). These ShakeMaps can be used for response, land use, and emergency planning purposes. The ShakeMap in Map 5 shows Pacific County.

Map 5: ShakeMap Showing the Modified Mercalli Shaking Intensity for a Cascadia M9 Earthquake



Note: Earthquake assessment in this report was completed only for a M9 scenario earthquake on the Cascadia subduction zone. Additional earthquakes have been modeled on other sources (DNR Scenario catalogue, https://fortress.wa.gov/dnr/seismicscenarios/), but none of them generate shaking intensity greater than MMI VI.

Earthquake Risk Assessment Overview

The earthquake risk assessment was completed using local parcel data from Pacific County and the ShakeMap in Map 5. For this study, individual building/parcel data from the County were incorporated into Hazus, which allow losses to be reported at the building level. The appendix provides detailed methodology on incorporating local data into Hazus. The results are summarized in Table 4.

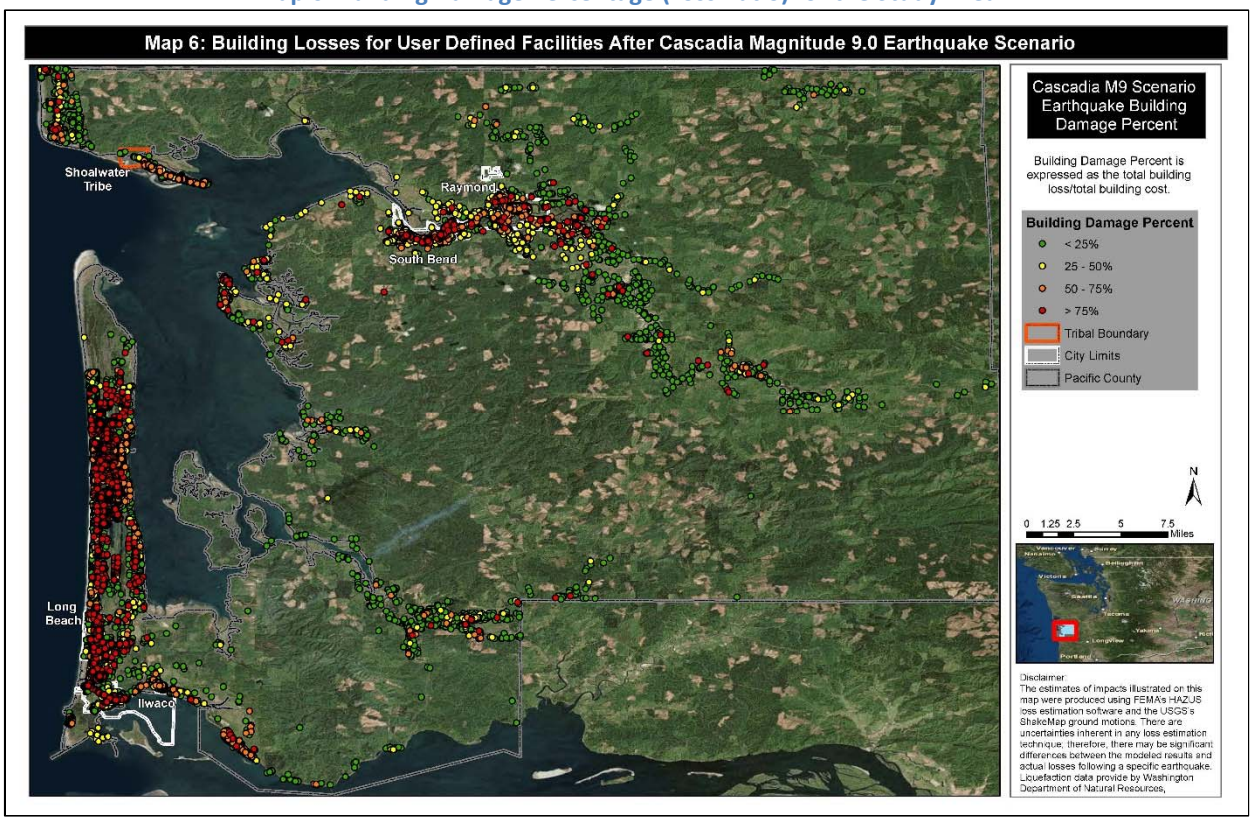
Table 4: Hazus Earthquake Results for a Scenario MW 9.0 Cascadia Earthquake

Community	Total Estimated Building Value	Total Number of Buildings	Number of Buildings in the Moderate – High Liquefaction Zone	Percent of Buildings in the Moderate-High Liquefaction Zone	Building Dollar Loss for a Cascadia 9.0 Event	Loss Ratio (Dollar Losses/Total Building Value)
Unincorporated County	$917,115,720	12,654	10,764	85%	$234,215,082	26%
Ilwaco	$87,997,658	669	453	68%	$28,013,411	32%
Long Beach	$154,513,884	1,406	1,406	100%	$43,572,222	28%
Raymond	$117,357,628	1,235	558	45%	$39,497,784	34%
South Bend	$82,052,427	790	459	58%	$32,841,868	40%
Shoalwater Bay Tribe	$5,388,653	41	35	85%	$814,499	15%
Total	**$1,364,425,970**	**16,795**	**13,675**	**81%**	**$378,954,866**	**28%**

Note: This table shows the total estimate building value by community, and the percentage and number of buildings within the high liquefaction zone. In addition, buildings losses and a loss ratio are reported for a Cascadia 9.0 event. A loss ratio is calculated by dividing the dollar loss by the total building value. The loss values are for building losses only; additional damages to infrastructure and building contents are not captured in this table.

The City of Long Beach and the Shoalwater Bay Tribe have the largest percentage of buildings located in the moderate-high liquefaction zone. Many of the communities will be substantially impacted if a Cascadia were to occur. The losses reported in Table 4 are for building losses only, and additional damage to infrastructure and building contents was not included. Therefore, these losses should be considered as a minimum. The building loss ratio for the entire county is shown on Map 6.

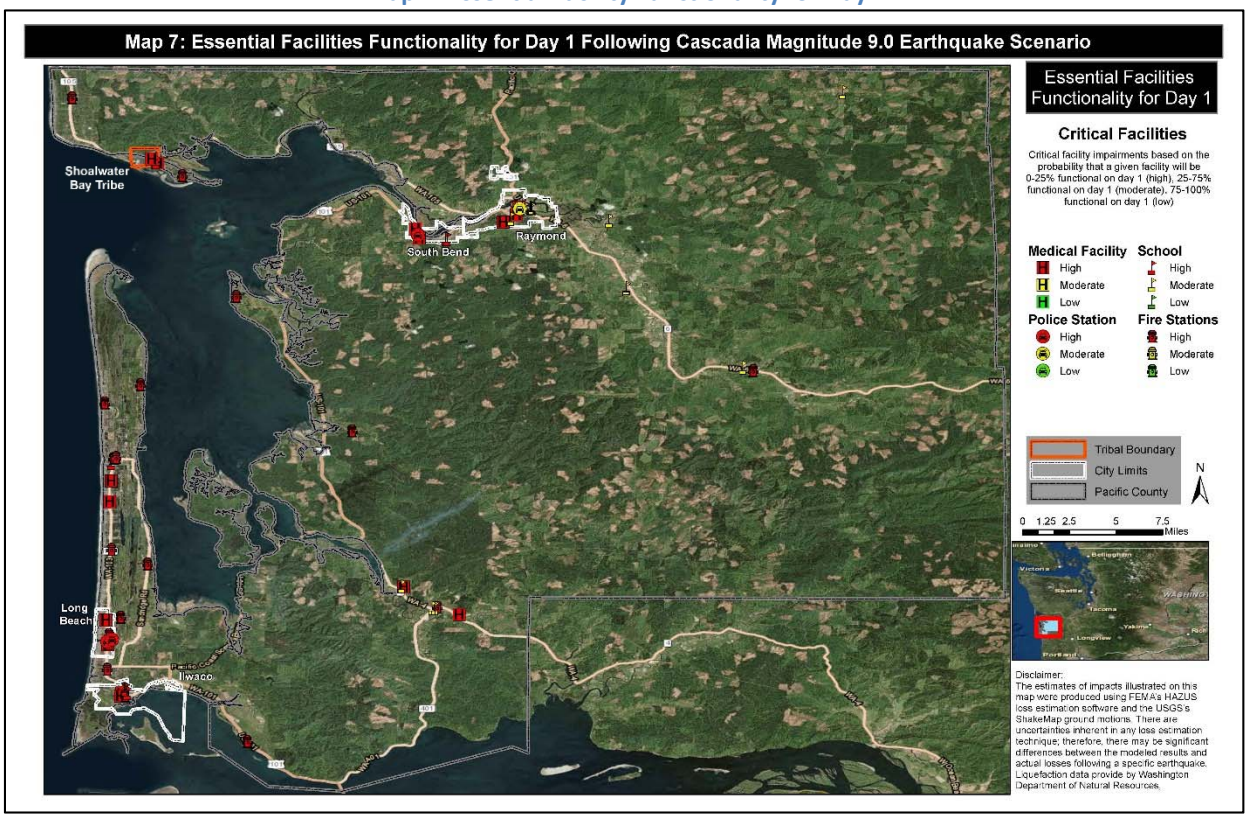
Map 6: Building Damage Percentage (Loss Ratio) for the Study Area



Note: The damage percentage is calculated by dividing the total building loss by the total building value. This percentage easily highlights the buildings in the community that would have the most damage. Only the building damage is shown above; other infrastructure damage was not included.

In addition to the building analysis, essential facilities (fire, police, medical facilities, and schools) were analyzed to determine if they would be functional on Day 1 after the earthquake. On Map 7, anything labeled “high” is expected to receive major damage and is therefore considered nonfunctional. For the entire study area, 38 percent of the schools, 75 percent of the police stations, 100 percent of the medical facilities, and 100 percent of the fire stations are expected to be nonfunctional on the day after the earthquake. Much of this area will need to rely on outside assistance, whether by air or road. Although transportation damage is not shown in the report, those data were analyzed for the risk assessment and will be provided to the communities for further planning.

Map 7: Essential Facility Functionality for Day 1



Note: Hazus determines building functionality on Day 1. Buildings shown in red are expected to have the most damage and therefore be nonfunctional.

The loss data from Hazus and the design code analysis can highlight the buildings and areas impacted by earthquakes and can be used to identify properties for mitigation projects, as well as areas for additional outreach. Highlighted areas of greatest impacts and potential mitigation actions are shown in the community sections of this report (Section 7).

An analysis was also completed to identify how many buildings were constructed to a specific building code. Hazus identifies key changes in earthquake building codes, based on year. Homes built prior to 1941 are considered pre-code; they were constructed before earthquake building codes were put in place. Homes constructed after 1941 are considered moderate code and may include some earthquake building components. The results of each type are summarized in Table 5.

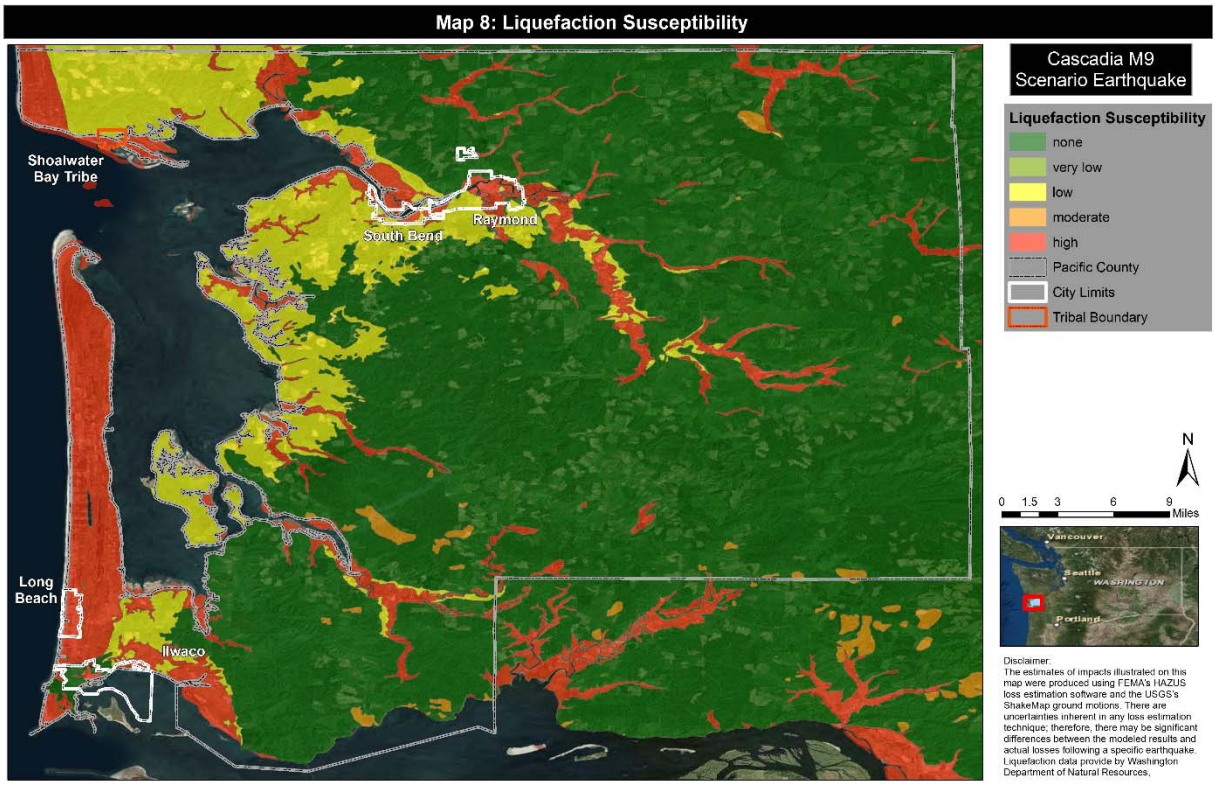
Tables 4 and 5 indicate that Raymond and South Bend have the highest loss ratios due to the number of pre-code structures in each community. Because of their age and pre-code status, these buildings will not perform as well in an earthquake.

Table 5: Pre-Code Versus Moderate Code Buildings in Pacific County

Community	Number of Pre-Code Buildings	Number of Moderate Code Buildings	Total Number of Buildings
Unincorporated County	1,746	10,908	12,654
Ilwaco	160	509	669
Long Beach	275	1,131	1,406
Raymond	946	289	1,235
South Bend	569	221	790
Shoalwater Bay Tribe	0	41	41
Pacific County Total	**3,696**	**13,099**	**16,795**

Liquefaction susceptibility describes the likelihood of sediments to liquefy, resulting in permanent ground deformations. The looser the soils, the more likely they are to liquefy. A value of 1 indicates no liquefaction susceptibility for that area (bedrock), 2 is very low, 3 is low, 4 is moderate, and 5 indicates a high liquefaction susceptibility. Map 8, which shows the liquefaction susceptibility for the entire study area, is significant because it shows a large percentage of buildings in a high-liquefaction area.

Map 8: Liquefaction Susceptibility in Pacific County



Moderate to high liquefaction susceptibility can result in greater damage to buildings during an earthquake. In addition to causing liquefaction, magnitude 9+ earthquakes can potentially trigger slope failures. Map 9 shows the slopes susceptible to the seismically induced shallow landslides associated with a M9+ Cascadia subduction zone earthquake in the area of Long Beach and Ilwaco (Slaughter and others, 2013).

The critical acceleration (a_c) is a relative predictor of slope performance that indicates which slopes are more likely to fail under a given earthquake magnitude. High is an a_c less than 0.2, medium is an a_c between 0.2 and 0.3, and low is an a_c between 0.3 and 0.4. Slopes with an a_c greater than 0.4 were not rated. The a_c between 0.0 and 0.4 were included in Map 9 for scenarios with the water table at the surface and at a depth of 3 feet; this represents a conservative mapping approach and the worst-case scenario for groundwater conditions.

For this risk assessment, the building data were compared to the geographic extent of the landslide hazard area. Map 9 shows areas where buildings are on slopes that are susceptible to shallow landslides. The surrounding buildings are also likely to be affected if they are within the slide-affected zone.

Map 9: Shallow Landslide Susceptibility Zones – Long Beach/Ilwaco Area

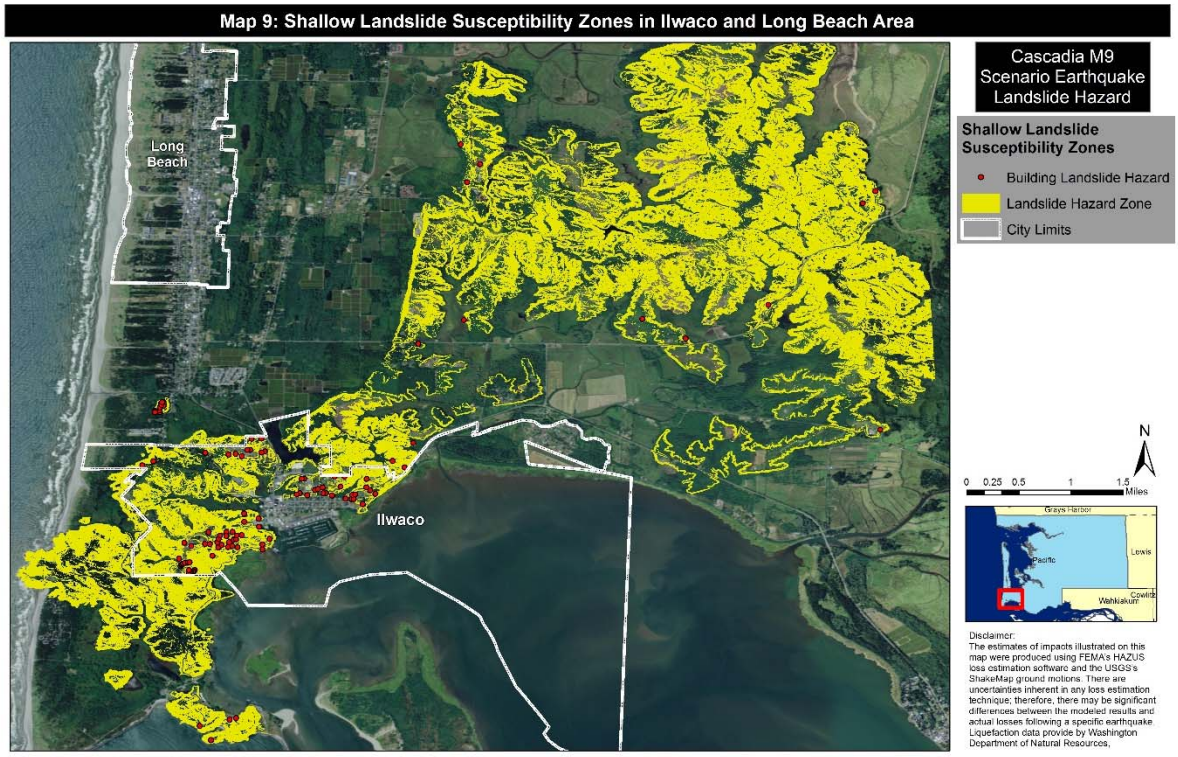


Table 6 shows the building value (in dollars) for each community in the shallow landslide susceptibility zones. This table also includes the number of buildings in the landslide zone and the total number of buildings and building values.

Table 6: Landslide Building Damage Costs

Community	Total Estimated Building Value	Building Value in Landslide Zone	Total Number of Buildings	Number of Buildings in Landslide Zone	Percentage of Buildings in Landslide Zone
Unincorporated County	$917,115,720	$4,319,267	12,654	32	0.25%
Ilwaco	$87,997,658	$13,377,027	669	80	11.96%
Long Beach	$154,513,884	Unknown	1,406	Unknown	N/A
Raymond	$117,357,628	Unknown	1,235	Unknown	N/A
South Bend	$82,052,427	Unknown	790	Unknown	N/A
Shoalwater Bay Tribe	$5,388,653	Unknown	41	Unknown	N/A
Total	**$1,364,425,970**	**$17,696,294**	**16,795**	**112**	**0.67%**

Updated landslide hazard information has been compiled for the coastal communities in Pacific County. Although other communities are shown as having no risk, this may not be the case. Additional analysis will need to be completed for areas in the eastern part of the county to better understand the landslide risk. Over 100 buildings, totaling close to $17.7 million in building value, are in the currently defined landslide zone. The landslide inventory assessment can be used to identify properties for mitigation projects as well as areas for additional outreach. The areas of greatest impacts and potential mitigation actions will be shown in the community sections of this report (Section 7). All results, databases, and maps are provided in the Risk Assessment Database included with this report.

6. Tsunami Risk Assessment

Tsunami Hazard Overview

Tsunamis are generated when geologic events, such as earthquakes or landslides, cause large, rapid movements in the sea floor that displace the water column above. That swift change creates a series of high-energy waves that radiate outward like pond ripples. Offshore tsunamis can strike adjacent shorelines in minutes and cross the ocean at speeds as great as 600 miles per hour to strike distant shores.

The coast of Washington is at risk from tsunamis of both local and distant origin. These destructive waves are most commonly caused by submarine earthquakes. Our current technology gives us adequate warning for tsunamis produced by distant quakes. However, an earthquake on the Cascadia subduction zone—like the 1700 event or an event from across the Pacific—could generate a tsunami that would strike our coast with great force within minutes.

The tsunami model for Pacific County is based on a Cascadia magnitude 9.0 (M9) earthquake. This tsunami model is based on the L1 scenario developed by the Pacific Marine Environmental Laboratory and data from Witter and others (2011). This scenario was selected because it is thought to represent the event with an annual probability of approximately 0.04 percent, or colloquially, the 2,500-year

event. This is a probability comparable to the International Building Code standard for earthquake loading for buildings of high importance. The publication of this modeling was released in early 2015.

Tsunami Risk Assessment

The arrival time and duration of flooding are key factors to consider for evacuation strategies. For locations on the outer coast, the first wave crest is generally predicted to arrive between 25 and 40 minutes after the earthquake, whereas the first crest is expected to arrive on the western shores of Willapa Bay after more than an hour and at South Bend in nearly two hours. Significant flooding can occur before the first crest arrives, because a Cascadia Subduction Zone earthquake is expected to lower the ground surface along the coast. Flooding of areas less than about 6 feet (1.8 m) above tide stage is expected soon after the earthquake, rendering evacuation time even shorter for people on the beach. Maximum flooding depth, velocity, and extent will depend on tide height at the time the tsunami arrives.

For this risk assessment, the building data were compared to the geographic extent of the tsunami. The results of the risk assessment are shown in Table 7.

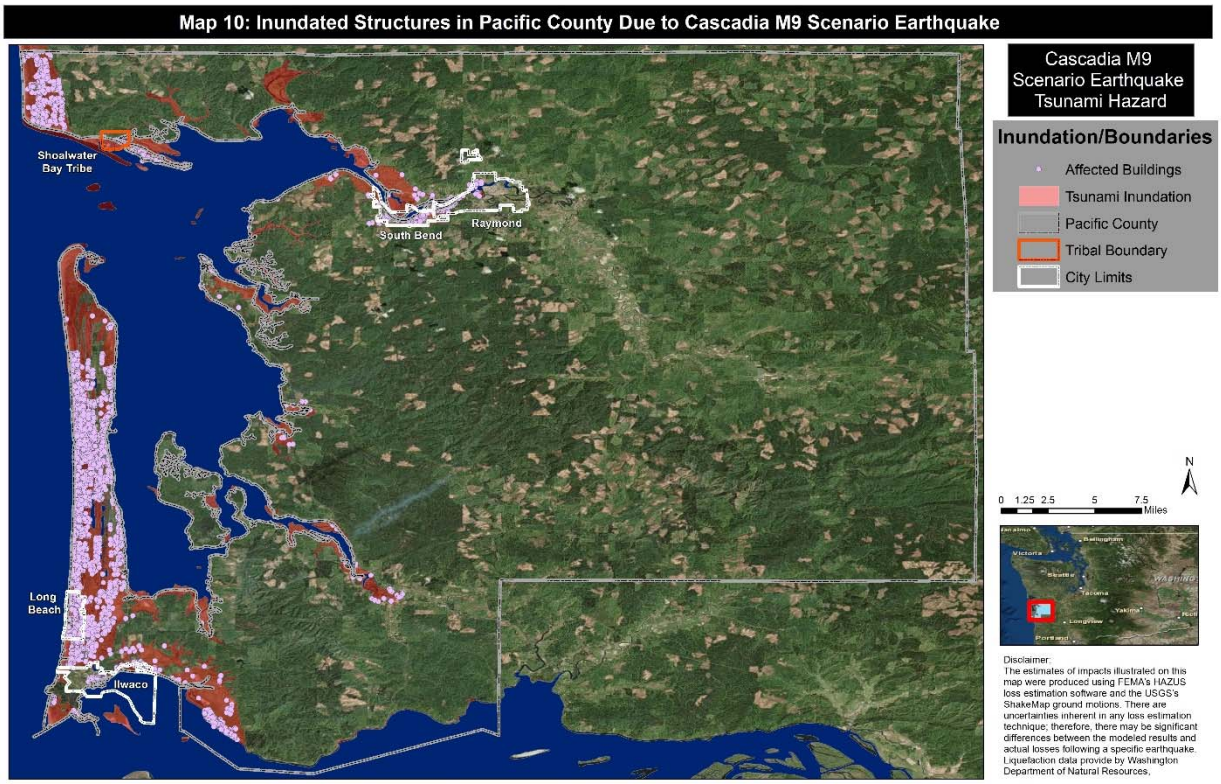
Table 7: Building Exposure Associated with a Cascadia M9 Earthquake-Induced Tsunami along Pacific County Coastal Region

Community	Total Estimated Building Value	Building Value in Tsunami Zone	Total Number of Buildings	Number of Buildings in Tsunami Zone	Percent of Buildings in Tsunami Zone
Unincorporated County	$917,115,720	$596,114,717	12,654	8,902	70.3%
Ilwaco	$87,997,658	$33,901,384	669	381	57.0%
Long Beach	$154,513,884	$154,513,884	1,406	1,406	100.0%
Raymond	$117,357,628	$7,067,249	1,235	83	6.7%
South Bend	$82,052,427	$38,699,479	790	417	52.8%
Shoalwater Bay Tribe	$5,388,653	$5,144,942	41	39	95.1%
Total	**$1,364,425,970**	**$835,441,654**	**16,795**	**11,228**	**66.9%**

Note: Estimates for each city are based on the new L1 model. The tsunami inundation for some areas in unincorporated Pacific County is based on an estimate, and new modeling is currently being planned.

For many communities along the coast, most of the built environment will be affected by a tsunami generated by a Cascadia M9 event. More than 11,000 buildings are expected to be affected by the tsunami, totaling close to $835 million in building value. Map 10 shows the locations of the impacted buildings and tsunami inundation area.

Map 10: Inundated Structures for a Tsunami Generated by the Cascadia M9 Scenario



The tsunami inventory assessment can be used to identify properties for mitigation projects as well as areas for additional outreach. Areas of greatest impact and potential mitigation actions will be shown in the community sections of this report (Section 7). All results, databases, and maps are provided in the Risk Assessment Database included with this report.

7. Areas of Mitigation Interest and Recommended Resilience Strategies

This section of the Risk Report takes risk findings from Hazus models and other hazard overlays and focuses on specific areas where mitigation efforts should occur. These areas, called Areas of Mitigation Interest (AOMI), were developed through conversations with the community during the Risk MAP process, as well as through analysis of various datasets for flood, earthquake, tsunami, and landslide hazards. The AOMI map targets areas where potential damage, economic loss, and casualties could occur from a hazard event. FEMA has provided resilience strategies for mitigation in these specific areas. These strategies are ways to reduce the risks to various hazards, thereby reducing potential damages, economic loss, and casualties during hazard events. The resilience strategies suggest potential projects for hazard mitigation, encourage local collaboration, and communicate how various mitigation activities can successfully reduce risk.

Section 7 of this report is broken down by individual community to create a more specific mitigation and resilience discussion for each jurisdiction.

Unincorporated Pacific County: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the county, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 8 highlights some of the buildings in the unincorporated areas of Pacific County that are affected by flooding, tsunami, earthquake, or landslide risks.

Table 8: Pacific County Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
Ocean Park Elementary School	25701 Vernon Ave	$5,400,000	$1,864,130	35%	Earthquake, Tsunami
Water Treatment Plant	5415 67th Pl.	$4,488,000	$1,692,110	38%	Earthquake
Ocean Park Library	1308 256th Pl., Ocean Park	$222,400	$81,745	37%	Earthquake, Tsunami
Willapa Valley School Dist. #160		$420,000	$192,843	46%	Earthquake
South County Administrative Building	7013 Sandridge Rd.	$3,376,900	$1,378,550	41%	Earthquake, Tsunami

Hazard Mitigation Plan Analysis

The Pacific County Hazard Mitigation Plan, effective through August 17, 2015, identified the following Hazard Mitigation Projects that can be aided by the information in this Risk Report.

Table 9: Pacific County Hazard Mitigation Plan Analysis

Hazard	Projects	Additional information from Risk Report
Multi-hazard	15. Gather additional data necessary to complete and improve future vulnerability assessments and GIS capability	Risk Report and Risk Database can support this action
Flood and Tsunami	18. Encourage the purchase of flood insurance in floodprone areas	Use Risk Report to target flood- and tsunami-prone areas for focused outreach
Earthquake	20. Provide non-structural earthquake mitigation to public buildings	Use Risk Report and Risk Database to prioritize buildings for mitigation

Recommended Resilience Strategies

Based on the discussion at the Resilience Workshop with Pacific County staff about the AOMIs, Hazard Mitigation Plan Analysis, and assessment above, the following strategies are a priority.

Table 10: Pacific County Recommended Resilience Strategies

Problem Statement	Recommended Strategies
85% of Pacific County's buildings are in the moderate-high liquefaction zone, and 14% are pre-code. Pacific County can expect a substantial impact if a Cascadia event occurs. Essential facilities and infrastructure are of particular concern and are likely to lose function immediately after the event.	• Check essential facility functionality for additional days post event o Highlight causes of functionality loss (structural v. non-structural) • Check tsunami evacuation routes for functionality post event • Develop priority list for essential facility earthquake retrofit
At least 32 buildings with a value totaling over $4 million are in shallow landslide susceptibility zones in the Ilwaco area. Essential facilities and infrastructure may also be exposed.	• Provide outreach to homeowners regarding the landslide risk • Consider limiting additional development in landslide hazard zones • Move or harden essential facilities and infrastructure in landslide hazard zones • Develop buyout program for homes in landslide areas
Over 8,900 buildings valued at over $596 million are in the tsunami zone; only 1,050 properties in the county have flood insurance, with coverage totaling about $247 million.	• Develop an outreach strategy to help homeowners, realtors, and insurance agents understand the value of flood insurance for tsunami risk
The County currently does not have a Long-Term Recovery Plan to address the policies, programs, and processes of how the county and cities will develop after a natural disaster	• The County is interested in developing a Long-Term Recovery Plan and is seeking funding and technical support. A FEMA Recovery Planner contacted the County after the meeting to assist. Impact data from the RiskMAP Risk Report and GIS Database can be used to identify key areas to rebuild.
It is currently unknown if each jurisdiction has created a Continuity of Operations Plan.	• The County will need to reach out to each jurisdiction to determine if a Continuity of Operations Plan is developed. If a plan is not developed, the County can contact the State or FEMA on guidance in developing a COOP.
Due to limited funding, lack of resources, and the isolation of Pacific County, there is no Mass Care Plan developed to identify food and shelter sites.	• The County can partner with the Red Cross to seek funding for a consultant to develop the Mass Care Plan. Partners include Pacific County Public Health, Hospital Districts 2 and 3, Raymond Fire and other fire districts, Sheriff's Department, Weyerhaeuser, and other timber and fishing industry representatives. Use the RiskMAP Risk Report and GIS Database to identify food and shelter sites that would receive minimum impacts to hazards.
The Pacific County Natural Hazard Mitigation Plan currently does not address the erosion hazard.	• The County will seek to include erosion as a hazard chapter in the current plan update process. In addition, the County should consider using the Department of Ecology erosion data to update the County erosion ordinance.

While Federal funding is limited, FEMA recommends incorporating the projects in Table 10 into the Pacific County Natural Hazard Mitigation Plan to implement if disaster funds become available. Additional funding may be available through the community's Capital Improvement Planning (CIP)

process, bond authority, or other local, State, or private funding source. More information on how to mitigate natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating the Hazard Mitigation Plan with the Local Planning Process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

City of Ilwaco: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the County, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 11 highlights some of the buildings in the City of Ilwaco that are affected by flooding, tsunami, earthquake, or landslide risks.

Table 11: City of Ilwaco Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
Ocean Beach Hospital	1st Ave N	$11,865,000	$4,843,650	41%	Earthquake
Ilwaco Landing LLC		$175,400	$32,428	18% (FL)	Flood
Grays Harbor College	208 Advent Ave SE	$1,200,000	$452,436	38%	Earthquake, Tsunami
Hilltop Bowl	601 1st Ave N	$165,700	$67,644	41%	Earthquake, Landslide
Ilwaco Community Center		$1,287,600	$525,637	41%	Earthquake
Ilwaco High School	404 School Rd	$5,257,200	$1,982,120	38%	Earthquake

Hazard Mitigation Plan Analysis

The City of Ilwaco does not have a FEMA-approved Hazard Mitigation Plan; completing one is strongly recommended.

Recommended Resilience Strategies

Based on the assessment above, the following resilience strategies are recommended.

Table 12: City of Ilwaco Recommended Resilience Strategies

Problem Statement	Recommended Strategies
At least 80 buildings with a total value of over $13 million are in shallow landslide susceptibility zones. Essential facilities and infrastructure may also be exposed.	• Provide outreach to homeowners regarding the landslide risk • Consider limiting additional development in landslide hazard zones • Move or harden essential facilities and infrastructure in landslide hazard zones • Develop a buyout program for homes in landslide areas
Over 380 buildings valued at over $33 million are in the tsunami zone; only 30 properties in the City have flood insurance, with coverage totaling about $6.5 million.	• Develop an outreach strategy to help homeowners, realtors, and insurance agents understand the value of flood insurance for tsunami risk

While Federal funding is limited, FEMA recommends incorporating these projects into the City of Ilwaco's Natural Hazard Mitigation Plan to implement if disaster funds become available. Additional

funding may be available through the community's CIP process, bond authority, or other local, State, or private funding source. More information on how to mitigate natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating a Hazard Mitigation Plan with the local planning process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

City of Long Beach: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the County, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 13 highlights some of the buildings in the City of Long Beach that are affected by flooding, tsunami, earthquake, and landslide risks.

Table 13: City of Long Beach Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
Worldmark	420 Sid Snyder Dr	$15,298,000	$5,767,810	38%	Earthquake, Tsunami
City of Long Beach		$318,143	$139,830	44%	Earthquake, Tsunami
Long Beach Post Office	101 Oregon Ave N	$143,200	$12,524	9%	Earthquake, Tsunami
World Kite Museum and Hall of Fame	303 Sid Snyder Dr W	$700,600	$264,147	38%	Earthquake, Tsunami

Hazard Mitigation Plan Analysis

The City of Long Beach participates in the Pacific County Hazard Mitigation Plan, effective through August 17, 2015, and identified the following Hazard Mitigation Projects that can be aided by the information in this Risk Report.

Table 14: City of Long Beach Hazard Mitigation Plan Analysis

Hazard	Project	Additional information from Risk Report
Flood and tsunami	4. Encourage the purchase of flood insurance in floodprone areas	Use Risk Report to target flood- and tsunami-prone areas for focused outreach
Earthquake	7. Provide non-structural earthquake mitigation to public buildings	Use Risk Report and Risk Database to prioritize buildings for mitigation

Recommended Resilience Strategies

Based on the assessment above, the following resilience strategies are recommended.

Table 15: City of Long Beach Recommended Resilience Strategies

Problem Statement	Recommended Strategies
All buildings in the City of Long Beach are in the moderate-high liquefaction zone, and 20% are pre-code. Long Beach can expect a substantial impact if a Cascadia event occurs. Essential facilities and infrastructure are of particular concern as they are likely to lose function immediately after the event.	• Check essential facility functionality for additional post-event days o Highlight causes of functionality loss (structural vs. non-structural) • Check tsunami evacuation routes for post-event functionality • Develop priority list for earthquake retrofit of essential facilities
All 1,406 buildings in the City, valued at over $154 million, are in the tsunami zone; only 135 of those properties have flood insurance (coverage totaling about $32 million).	• Develop an outreach strategy to help homeowners, realtors, and insurance agents understand the value of flood insurance for tsunami risk

While Federal funding is limited, FEMA recommends incorporating these projects into the City of Long Beach's Natural Hazards Mitigation Plan to implement if disaster funds become available. Additional funding may be available through the community's CIP process, bond authority, or other local, State, or private funding source. More information on how to mitigate natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating a Hazard Mitigation Plan with the local planning process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

City of Raymond: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the County, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 16 highlights some of the buildings in the City of Raymond that are affected by flooding, tsunami, earthquake, and landslide risks.

Table 16: City of Raymond Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
Weyerhaeuser Sawmill	51 Ellis St	$14,399,200	$7,658,220	53%	Earthquake
City of Raymond		$318,143	$169,205	53%	Earthquake
Valley View Health Center	300 Ocean Ave	$366,700	$195,029	53%	Earthquake
Raymond School District #116		$5,555,200	$2,954,530	53%	Earthquake

Hazard Mitigation Plan Analysis

The City of Raymond participates in the Pacific County Hazard Mitigation Plan, effective through August 17, 2015, and identified the following Hazard Mitigation Projects that can be aided by the information in this Risk Report.

Table 17: City of Raymond Hazard Mitigation Plan Analysis

Hazard	Project	Additional information from Risk Report
Flood and tsunami	2. Encourage the purchase of flood insurance in floodprone areas	Use Risk Report to target flood- and tsunami-prone areas for focused outreach
Earthquake	5. Provide non-structural earthquake mitigation to public buildings	Use Risk Report and Risk Database to prioritize buildings for mitigation
Flood	Maintain plans to relocate fire and police equipment and command and control	Use Risk Report and Risk Database to identify areas of low risk as sites for relocation

Recommended Resilience Strategies

Based on the assessment above, the following resilience strategies are recommended.

Table 18: City of Raymond Recommended Resilience Strategies

Problem Statement	Recommended Strategies
Approximately 75% of the buildings in Raymond were built before modern building codes. This could result in significant damage during an earthquake. Pre-code essential facilities are of particular concern.	• Develop a priority list for essential facility earthquake retrofits • Develop an outreach or mitigation program for homeowners and businesses to retrofit older buildings

While Federal funding is limited, FEMA recommends incorporating these projects into the City of Raymond's Natural Hazards Mitigation Plan to implement if disaster funds become available. Additional funding may be available through the community's CIP process, bond authority, or other local, State, or private funding source. More information on how to mitigate for natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating a Hazard Mitigation Plan with the local planning process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

City of South Bend: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the County, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 19 highlights some of the buildings in the City of South Bend that are affected by flooding, tsunami, earthquake, and landslide risks.

Table 19: City of South Bend Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
South Bend City Hall		$253,200	$102,237	40%	Earthquake, Tsunami
South Bend Fire Department		$170,300	$68,764	40%	Earthquake, Tsunami
South Bend Library		$170,200	$68,723	40%	Earthquake, Tsunami

Hazard Mitigation Plan Analysis

The City of South Bend participates in the Pacific County Hazard Mitigation Plan, effective through August 17, 2015, and identified the following Hazard Mitigation Projects that can be aided by the information in this Risk Report.

Table 20: City of South Bend Hazard Mitigation Plan Analysis

Hazard	Project	Additional information from Risk Report
Flood and tsunami	7. Encourage the purchase of flood insurance	Use Risk Report to target flood- and tsunami-prone areas for focused outreach
Earthquake	10. Provide non-structural earthquake mitigation to public buildings	Use Risk Report and Risk Database to prioritize buildings for mitigation

Recommended Resilience Strategies

Based on the assessment above, the following resilience strategies are recommended.

Table 21: City of South Bend Recommended Resilience Strategies

Problem Statement	Recommended Strategies
• Over 400 buildings valued at over $38 million are in the tsunami zone; only 100 properties in the City have flood insurance, with coverage totaling about $12 million.	• Develop an outreach strategy to help homeowners, realtors, and insurance agents understand the value of flood insurance for tsunami risk
• Approximately 70% of the buildings in South Bend were built before modern building codes. This could result in significant damage during an earthquake. Pre-code essential facilities are of particular concern.	• Develop a priority list for earthquake retrofits of essential facilities • Develop an outreach or mitigation program for homeowners and businesses to retrofit older buildings

While Federal funding is limited, FEMA recommends incorporating these projects into the City of South Bend's Natural Hazards Mitigation Plan to implement if disaster funds become available. Additional funding may be available through the community's CIP process, bond authority, or other local, State, or private funding source. More information on how to mitigate natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating a Hazard Mitigation

Plan with the local planning process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

Shoalwater Bay Tribe: Areas of Mitigation Interest and Recommended Resilience Strategies

An overall hazard assessment that was completed for the County, based on the Hazus risk assessment, includes the buildings most at risk from multiple hazards. Table 22 highlights some of the buildings in the Shoalwater Bay Tribal area that are affected by flooding, tsunami, earthquake, and landslide risks.

Table 22: Shoalwater Bay Tribe Areas of Mitigation Interest

Community Building Name	Address	Building Value	Loss Value	Loss Ratio	Hazard Type
Shoalwater Bay Tribe	2364 Breezy Way	$318,143	$89,207	28%	Earthquake, Tsunami
Shoalwater Bay Casino		$318,143	$89,207	28%	Earthquake, Tsunami

Hazard Mitigation Plan Analysis

The Shoalwater Bay Tribe Hazard Mitigation Plan, effective through September 11, 2019, identifies the following Hazard Mitigation Projects that can be aided by the information in this Risk Report. An update of the plan is strongly recommended.

Table 23: Shoalwater Bay Tribe Hazard Mitigation Plan Analysis

Hazard	Project	Additional information from Risk Report
Multi-hazard	T-1. Flood elevate homes and buildings	Use Risk Report and Risk Database to identify homes and buildings of highest need and benefit/cost ratio
Multi-hazard	T-2. Acquire properties in low hazard areas in order to locate new development or relocate existing vulnerable structures and critical facilities	Use Risk Report and Risk Database to identify high-priority facilities to move to low-hazard areas
Multi-hazard	T-7. Seismic retrofit of tribal buildings and infrastructure, including a reservation-wide back-up generator system	Use Risk Report and Risk Database to identify high-priority facilities for retrofit
Multi-hazard	T-16. Develop Building Codes and a Development/Master plan that focuses new development and construction on less vulnerable locations	Use Risk Report and Risk Database to identify areas at lowest risk to hazards
Multi-hazard	T-17. Create a community-wide comprehensive education program to educate the Tribe about hazards and hazard mitigation	Use Risk Report and Risk Database as a basis for education program

Recommended Resilience Strategies

Based on the discussion with tribal staff at the Resilience Workshop about the AOMIs, Hazard Mitigation Plan Analysis, and assessment above, the following resilience strategies are a priority.

Table 24: Shoalwater Bay Tribe Recommended Resilience Strategies

Problem Statement	Recommended Strategies
The Shoalwater Bay Tribe has 85% of its buildings in the moderate-high liquefaction zone, and all are moderate code. Shoalwater Bay Reservation can expect substantial impacts if a Cascadia event occurs. Essential facilities and infrastructure are of particular concern and are likely to lose function immediately after the event.	• Check essential facility functionality for additional post-event days • Highlight causes of functionality loss (structural vs. non-structural) • Check tsunami evacuation routes for post-event functionality • Develop priority list for earthquake retrofits of essential facilities
Almost all buildings on the Shoalwater Bay Reservation, valued at over $5 million, are in the tsunami zone; none of these buildings have flood insurance coverage through the NFIP.	• Complete a detailed analysis of the cost of coverage for the buildings on the Reservation
The Shoalwater Bay Tribe is currently developing the tribe's first comprehensive plan, but it does not include the recent RiskMAP data.	• Take the RiskMAP data to the comprehensive plan contractor to discuss integrating it into the comprehensive plan and determine how the information can be used to identify safer areas for building
The Tribal Center (Administration Building) is currently vulnerable to various hazards due to its location.	• Review the new RiskMAP data to determine possible safe areas for relocation. Use the current comprehensive plan development process to ensure land is identified for the Tribal Center
The Eagle Hill/Annex Compound is identified as a possible tsunami safe zone, but the routes to get to the area are not clearly identified.	• Conduct a study for possible evacuation routes to the Eagle Hill/Annex Compound Tsunami Safe Zone.

While Federal funding is limited, FEMA recommends incorporating the projects in Table 24 into the Shoalwater Bay Tribe's Natural Hazards Mitigation Plan to implement if disaster funds become available. Additional funding may be available through the Tribe's CIP process, bond authority, or other local, State, or private funding source. More information on how to mitigate natural hazards can be found in the FEMA Local Mitigation Planning Handbook (http://www.fema.gov/media-library/assets/documents/31598?id=7209). Additional information on integrating a Hazard Mitigation Plan with the local planning process can be found here: http://www.fema.gov/media-library/assets/documents/19261?id=4267.

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9. Appendices

Hazus Methodology

This section of the report is intended to provide documentation for the Hazus-MH data update and Hazus Flood and Earthquake analyses that were used by the Washington State Department of Natural Resources – Division of Geology and Earth Resources (WADNR-DGER) to highlight the loss estimations for the communities of Pacific County.

Disclaimer: The model referenced in this document does not replace or supersede any other official document or product generated to meet the requirements of any State, Federal, or local program. It is intended for planning purposes only. This document and its contents have been prepared and are intended solely for Pacific County's information and use. The WADNR-DGER assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

GIS layers

The Hazus-MH General Building Stock (GBS) data are reported by U.S. Census block (flood model) or tract (earthquake model). Because the GBS data are generalized by geographic boundaries, they are referred to as aggregate data and limit the loss estimation analyses for small communities that require consideration of each building in the analyses. Therefore, the individual building data were prepared using the country assessor's data, commonly called User Defined facilities (UDFs), and were incorporated into Hazus, which allows losses to be reported at the building level. The essential facilities (EFs) and GBS data were also updated ("Level 2") using the UDFs.

User Defined Facility (UDF) Layer:

- Main input source for the Hazus formatted UDF data is county assessor's (or parcel) data.
- The assessor's data, however, needed to be reformatted and/or evaluated for the missing information, such as tax exempt properties (government, nonprofit organizations, etc.).
- The WADNR-DGER prepared complete HAZUS-formatted UDF data using the following order:
    - Received building physical information and building value from the county's parcel data.
    - Used parcel data ESRI (polygon) shape file to generate centroids, thus approximate building locations
    - Consolidated repeated parcel numbers based on building values and areas
    - Verified building physical properties and values by using the website search (process was done automatically by using the Microsoft Excel and VBA scripts).
    - Completed building data for parcel polygons that contained multiple units (mobile homes, school campuses, compounds, airport facilities, etc.) by using the ESRI ArcGIS 10.0 and OrthoPhoto acquired in 2013 (ESRI Basemap)
    - Completed the missing building square footage information by using footprints of the buildings calculated on 2013 OrthoPhoto image or Lidar Foot Print data (if provided)

Acronyms and Definitions

AOMI	Area of Mitigation Interest
BFE	Base Flood Elevation
CCO	Community Coordination Officer
CIP	Capital Improvement Plan
COG	Continuity of Government
COOP	Continuity of Operations Plans
CDMS	Comprehensive Data Management System
DGER	Division of Geology and Earth Resources
EF	Essential Facility
EOP	Emergency Operations Plans
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FRR	Flood Risk Review
GBS	General Building Stock
LiDAR	Light Detection and Ranging
LOMA	Letters of Map Amendment
NEHRP	National Earthquake Hazards Reduction Program
NFIP	National Flood Insurance Program
PNSN	Puget Sound Seismic Network
Risk MAP	Risk Mapping, Assessment, and Planning
SFHA	Special Flood Hazard Area
STARR	Strategic Alliance for Risk Reduction
UDF	User Defined Facility
USGS	U.S. Geological Survey
WADNR	Washington State Department of Natural Resources

Additional Resources

Hazus-MH Earthquake Model

Technical Manual: http://www.fema.gov/media-library-data/20130726-1820-25045-6286/hzmh2_1_eq_tm.pdf

User Manual: http://www.fema.gov/media-library-data/20130726-1820-25045-1179/hzmhs2_1_eq_um.pdf

Comprehensive Data Management System:

Data Dictionary: http://www.fema.gov/media-library-data/20130726-1749-25045-0320/cdms_data_dict.pdf

Hazus-MH Flood Model

Technical Manual: http://www.fema.gov/media-library-data/20130726-1820-25045-8292/hzmh2_1_fl_tm.pdf

User Manual: http://www.fema.gov/media-library-data/20130726-1820-25045-8814/hzmh2_1_fl_um.pdf

USGS Shakemap Scenarios:

http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Casc9.0_expanded_se/

WA Geological Information Portal:

https://fortress.wa.gov/dnr/geology/ or
http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/geology_portal.aspx